Method of Test for
DETERMINING THE LONGITUDINAL
PROFILE ROUGHNESS OF TRAVELED SURFACES
USING AUTOMATED PROFILERS
DOTD Designation: TR 644-06

INTRODUCTION

This method describes the procedure to be used for measuring and reporting the longitudinal profile roughness of traveled surfaces using an inertial profiler (automated profiler). Inertial profilers are devices used to produce a filtered approximation of the "true" pavement profile using non-contact sensors to measure the relative displacement between the vehicle frame and road surface.

Surface data that is obtained by this method can be reported as International Roughness Index (IRI) or Profile Index (PI); however, DOTD TR 641 is the department's official standard for Profile Index. When the inertial profiler is allowed as an alternate device for measuring PI, the results must correlate with the results generated by an approved 25 ft California Type Profilograph in accordance with project specifications.

Whereas profile index is a measure of deviations from a smooth plane, the IRI simulates a vehicle's response to the deviations. IRI values are calculated on a quarter-car mathematical model that simulates the suspension characteristics of a passenger car to the collected profile. This test procedure is the department's official standard for determining the average IRI of pavement surfaces.

Only approved profilers can be used on DOTD projects. Profilers are evaluated and certified annually by the Materials and Testing Section to ensure conformance with the apparatus requirements of this procedure. The Texas Transportation Institute (TTI) Certification for Lightweight Profilers will suffice via reciprocity for LADOTD certification, providing the decal has the proper information. In addition, the precision and bias of IRI measurements using the profiler on test sections of known values are determined during the evaluation program. After 10 test runs, the standard deviation of the IRI results obtained from the profiler must not exceed 3 inches per mile for each sensor. The mean IRI value shall be within ±6 percent of the reference IRI as determined by the department's Australian Road Research Board (AARB) Walking Profiler. Approved profilers are identified with a verification decal indicating the certification expiration date, the certification number, and profiler system parameter settings.

Recertification of profilers is required annually and whenever major component repairs, replacements, or modifications are made to the accelerometer and its associated hardware, sensors and its associated hardware, distance transducer, data acquisition system, or tire replacement. Minor repairs and adjustments can be performed without having the profilers recertified provided the profiler system meets the pre-operation test requirements shown in this procedure. Minor repairs and adjustments include re-soldering or replacing connectors, cleaning components, tire pressure adjustments, adjusting sensor spacing to align over wheelpaths, and setting software parameters as shown in this procedure. Recertification of profilers is also required when requested by the department. Each profiler shall have a field book that shows certification dates as well as dates and descriptions of all major repairs, component replacements, and other modifications. Field books shall also include a record of each pre-op test and tire pressure for each day of testing.

The automated profiler is to be equipped with a laptop computer. Depending on the software supplied and software upgrades over time, the computer output could possibly be much more complex than covered in this procedure. However, this procedure will only cover those areas necessary for the acquisition of IRI and PI values for roadway projects.

DOTD Designation TR 644-06

I. Scope

A. This method describes the procedure for measuring and reporting the longitudinal profile roughness of a pavement's surface using the inertial profiler. Also included in this procedure are standard pre-operation tests to verify the calibration of the profiler.

B. Ride quality as determined from this procedure is reported as the International Roughness Index (IRI) and Profile Index (PI).

II. Apparatus

A. **Approved inertial profiler** – a device that has been approved by the Materials Engineer Administrator, configured to meet the requirements of ASTM E950 Class I or II. Approved profilers are designated with a decal indicating the certification expiration date, certification number, speed at which profiler must be operated, tire pressure, filter settings as verified or determined by the Materials and Testing Section, and whether or not the profiler is approved for IRI, PI, or both types of measurements. The profiler shall include at a minimum:

1. A vehicle large enough to accommodate all the required equipment without major structural modifications. The engine, steering mechanisms, and suspension components shall be adequate to allow smooth maintenance of speed and direction of travel.

B. **Data Acquisition and Reporting System -** mounted on the vehicle, to store and process sensor, accelerometer, and distance measurement data. This system must be capable of producing an electronic file recognized by the ProVal Software, such as .erd format, along with a paper copy of daily results in conformance with the reporting requirements of this procedure. The system is to come equipped with an automatic triggering device that can immediately activate a start and stop point when a reflective tape or cone is passed. The data acquisition system shall include an "event" key or "omit" button that will identify excluded areas which are not to be included in IRI or PI calculations. The computer hardware shall be IBM compatible and must contain a USB Port and USB storage device. The printer shall be a high speed thermal printer or laserjet. The computer system shall be equipped with a Microsoft Windows operating system. The software shall be capable of calculating IRI and PI in accordance with the segment lengths shown in this procedure. The software shall also accommodate system set up and pre-operation tests in accordance with the requirements in this procedure. Also required are the following:

1. Non-contact Height Sensor(s) mounted on the vehicle with its measuring axis perpendicular to the traveled surface and in line with the sensitive axis of the accelerometer. The sensors shall be housed in a manner to protect the lasers or infrared sources from damage when not used.
2. Accelerometer(s) mounted on the vehicle with its sensitive axis perpendicular to the traveled surface.
3. Distance Transducer capable of measuring travel distance of the vehicle within 0.1% of the actual distance traveled.
4. Adjustable alignment bar approximately 3 ft in length mounted on the front end of the vehicle. The configuration of the bar shall be such that it can be used to maintain alignment of the non-contact sensors over the wheelpath(s) while taking surface roughness measurements.
5. The sample interval shall not exceed 6 inches. The report interval must be les than or equal to 6 inches.
6. The high pass filter must be set at 300 feet.

C. **Metal Calibration Blocks** – provided by the profiler manufacturer, for the validation of the non-contact sensors in accordance with the Vertical Test shown in Appendix B. The blocks shall consist of a base plate and gage blocks having thicknesses of 0.25 in., 0.50 in. and 1.00 in or a set of blocks to perform an equivalent series of calibration tests.

The acceptable thickness tolerance for each block is ±0.01 in.

D. **Portable Air Pump and Tire Pressure Gage**
E. **Measuring Tape/Measuring Wheel** – minimum 100 ft measuring tape
F. **Transport Vehicle** – for transporting the inertial profiler and supporting equipment.
G. **Certification Report** – for inertial profiler. (Figures 1A and 1B)
H. **Field Book** – A bound record book containing certification dates and dates and descriptions of repairs, component replacements, modifications as required in the Introduction of this procedure. The field book shall also show the operator's name, tire pressure, pre-op test results, lot number, sublot number, type of pavement, project numbers, dates tested, file names that correspond to each test run that is performed on state projects.
I. **Marker** – Paint, stakes, etc.
J. **Suitable cleaning material –** as recommended by the manufacturer for cleaning non-contact sensor and other essential equipment.
K. **Alignment Bar (for lightweight profilers only)** – located on the front of the profiler to maintain sensor alignment over the wheelpath(s).
L. **Pavement Report Form** - Portland Cement Concrete Pavement Report (DOTD Form 03-22-4035, Figure 2A) or Asphaltic Concrete Pavement Report (DOTD Form 03-22-4199, Figure 2B).

III. Terminology

A. **International Roughness Index (IRI)** – A number used to estimate the amount of roughness in a measured longitudinal profile. IRI is based on the response of a generic passenger vehicle to roughness of the road surface. It was developed as a reference measurement by The World Bank, and is based on a quarter car simulation as described in National Cooperative Highway Research Program (NCHRP) Report 228 and in the introduction of this procedure.
B. **Excluded Areas** – Areas that are not included in the calculations for surface roughness for the lot. Excluded areas are identified by the Project Engineer and may be measured separately for surface roughness. Examples include crossovers, driveways, railroad crossings, bridges, manholes, etc.
C. **Report Interval -** The travel distance between recorded elevation readings as collected by the inertial profiler used to measure roughness.
D. **High Pass Filter (Long Wavelength) –** the mathematical transformation which removes long wavelengths.
E. **Non-contact sensors –** Laser or infrared sensors that measure the distance between the accelerometer on the profiler and the traveled surface. Non-contact sensors are mounted on the vehicle with its measuring axis perpendicular to the traveled surface.
F. **Wheel path** – For the purpose of this procedure, the wheel path is defined as 3±1/2 ft on either side of the centerline of the lane to be tested.

IV. Test Section

Note 1: *Refer to the specifications for the number of wheel paths and section lengths that are required to be tested.*

A. Identify and mark the beginning and ending points of the lane to be tested. The direction of travel of the inertial profiler shall be consistent with the travel direction of the lane, except in extenuating circumstances such as areas which would not otherwise have sufficient lead-in.

Note 2: *Begin the test section at the end of the previous test section when testing continuous sections of new pavement.*

B. Identify and mark excluded areas that are within the test section.
C. Assure test path is free of standing water and loose debris.

V. Preparation

A. Remove the profiler from the transport trailer and place on a flat and level surface.
B. Turn on the laptop computer and the processing computer.

Note 3: *On some units, the ignition key must be turned on in order for the laptop and processing computers to operate.*

C. Check and adjust the tire pressure for each tire on the profiler in accordance with the manufacturer's recommendations. Drive the unit for 15 to 20 minutes to warm the tires.
D. Securely fasten the alignment bar and non-contact sensor(s) so that the sensor(s) will be aligned over the wheelpath(s) of the test section.
E. Slide the protective cover that is located beneath each sensor to expose the lasers and, if necessary, clean each laser with manufacturer's recommended cleanser to remove foreign matter.

Note 4: *The reflection of the laser on the pavement surface will be faintly visible when the protective cover is removed. Never look directly into the laser openings since lasers are harmful to the eyes.*

F. Perform the Set Up procedures in Appendix A.
G. Perform the Pre-Operation tests in accordance with Appendix B before taking surface roughness measurements each day and whenever the operator or inspector suspects changes in system performance.

VI. Procedure

A. Input the following into the computer: the beginning station number, operator's name, project number, direction of travel, lot number, sublot number, location from centerline, and type of pavement for the test section according to the manufacturer's instructions. Include roadway side (left or right) and directions (NSEW) in the remarks.
B. Accelerate the profiler so that it is collecting accurate profile data as recommended by the manufacturer (see appendix). Once manufacturer recommendations are achieved, it is required that at least 300 feet of profile data be collected as a lead-in to all test sections.
C. When the beginning point of the test section is reached, activate the data acquisition system according to the manufacturer's instructions. If both wheelpaths are to be tested, then both sensors must be activated simultaneously so that only one pass of the profiler is needed. If only one wheelpath is to be tested, then the sensor corresponding to the inside wheelpath must be activated unless otherwise directed by the project specifications.
D. Maintain a constant speed throughout the test section while keeping the non-contact sensor(s) located over the wheelpath(s), by using an alignment bar.
E. Flag or omit taking readings at excluded areas with the event key or omit button.

Note 5: *On some profilers, it is necessary to continue depressing the event key or omit button until the exclusion is cleared.*

F. At the end of the test section, end the data collection and save the data files.
G. Copy the data files in a format recognized by ProVal for each wheelpath to the USB Storage Device. Record the project information in the field book, including file names of the data files, as required in accordance with Step II.B
H. Print a computer generated report containing the information in Step VIII.A.
I. Repeat the pre-operation tests in accordance with Step V.G. at the end of day to ensure collected data is valid.

VII. Calculations

A. International Roughness Index:

Note 6: *The IRI is calculated to the nearest 0.1 inch per mile based on a quarter-car mathematical model in accordance with AASHTO PP37. The sample interval used in the calculations shall not exceed 6 in.*

If the test section is split such that a single run is not possible, then use the following formula to calculate the test section average (IRI), to the nearest 0.1 in./mile:

$$IRI = \frac{L_1(IRI_1) + L_2(IRI_2) + \ldots L_n(IRI_n)}{(L_1 + L_2 + \ldots + L_n)}$$

where,

L_1, L_2, L_n = length of each run in feet that correspond with IRI_1, IRI_2, through IRI_n.

IRI_1, IRI_2, IRI_n = Average IRI values in inches per mile that corresponds to each single run within a split test section.

Example:

L_1 = 1000 ft
IRI_1 = 65 in./mile
L_2 = 3000 ft
IRI_2 = 70 in./mile
L_3 = 2000 ft
IRI_3 = 60 in./mile

$$IRI = \frac{1000(65) + 3000(70) + 2000(60)}{1000 + 3000 + 2000}$$

$$= \frac{65000 + 210000 + 120000}{6000}$$

$$= \frac{395000}{6000}$$

$$= 65.833 \text{ in./mile}$$

$$= 65.8 \text{ in./mile}$$

B. Profile Index:

If the test section is split such that a single run is not possible, then use the following formula to calculate the test section average PI, to the nearest 0.1 in./mile:

$$PI = \frac{L_1(PI_1) + L_2(PI_2) + \ldots + L_n(PI_n)}{L_1 + L_2 + \ldots + L_n}$$

where,

L_1, L_2, L_n = length of each run in feet that correspond with PI_1, PI_2, through PI_n.

PI_1, PI_2, PI_n = Average PI values in inches per mile that corresponds to each single run within a split test section.

Example:

L_1 = 2500 ft
IRI_1 = 4.3 in./mile
L_2 = 2300 ft
IRI_2 = 4.1 in./mile

$$PI = \frac{2500(4.3) + 2300(4.1)}{2500 + 2300}$$

$$= \frac{10750 + 9430}{4800}$$

$$= \frac{20180}{4800}$$

$$= 4.204 \text{ in./mile}$$

$$= 4.2 \text{ in./mile}$$

VIII. Report

A. **Profiler Report:**

A computer generated report containing the following information shall be given to the inspector for the project files upon completion of the test:

1. Profiler serial number
2. Operator's name
3. DOTD Inspector's name
4. Electronic file name
5. Project number
6. Route/Highway number
7. Parish/County
8. Test Section Number
9. Test Date
10. Weather conditions; principally temperature, cloud cover, and wind (Optional)
11. Lane measured
12. Reduction Length
13. Calpro Settings (for PI only)
14. Filter setting
15. Plotting settings (Optional)
16. Profile data:
    a. Stations tested
    b. Bump/Dip Locations
    c. Average IRI or PI per wheelpath (as required by specifications) for each 0.05 mile (for IRI) or 0.1 mile (for PI) segment within the sublot being tested.

d. Average IRI or PI for values obtained in Step VIII.16c.
e. Average IRI or PI for the Test Section

B. **Pavement Report**

1. Report the average IRI for the test section as Average International Roughness Index to the nearest in./mile on the appropriate pavement report form.
2. Report the average PI for the test section as Average Profile Index to the nearest 0.1 in./mile on the appropriate pavement report form.

IX. **Normal Test Reporting Time**

Normal test reporting time is 2 hours.

Rev. 01/06

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
PROFILER INSPECTION AND CERTIFICATION

GENERAL INFORMATION

Calibration Sticker Number:

Laptop Serial Number: _____ Mfg./Model: _____

VIN: _____ Processing Computer Serial Number: _____

Laser S/N (#1): _____ (#2) _____

Owner: _____ Telephone #: _____

Address: _____ City/State: _____

Prior Inspection Date: _____ Test Date: _____

Tire Pressure, psi (Record all tires) RF: _____ RR: _____ LF: _____ LR: _____

INSPECTION AND TESTING

1. Miscellaneous Apparatus (Must be available at the time of inspection)
   - A. _____ Tire pressure gauge
   - B. _____ Air pump
   - C. _____ 3-Foot alignment bar, adjustable
   - D. _____ 100-ft minimum Measuring Tape or Measuring Wheel
   - E. _____ Transport vehicle, trailer
   - F. _____ Owner's manual
2. Field Book
   - A. _____ Available B. _____ Up-to-Date (Upgrades Recorded?) Yes ____ No ____
3. Optical Digital Sensors (ODS) _____ Clean
4. Calibration Blocks
   - A. 0.25 inch, other _____ inch, Thickness _____ (±0.01)
   - B. 0.50 inch, other _____ inch, Thickness _____ (±0.01)
   - C. 1.00 inch, other _____ inch, Thickness _____ (±0.01)
5. Data Acquisition and Reporting System
   - A. _____ IBM Compatible system
   - B. _____ USB Port
   - C. _____ High speed thermal strip plotter
   - D. _____ Omit, Event key or method
   - E. _____ Thermal Printer
   - F. _____ Calculates IRI, 0.05 mile segment
   - G. _____ Calculates PI, 0.10 mile segment
   - H. _____ Bump detection feature

STATIC TESTS

6. Vertical Calibration Check

Extensive Test					
ODS #1			ODS #2		
Block Size	Avg. Diff.	Tolerance	Block Size	Avg. Diff.	Tolerance
0.25 (other)		Less than 0.01	0.25 (other)		Less than 0.01
0.50 (other)		Less than 0.01	0.50 (other)		Less than 0.01
1.00 (other)		Less than 0.01	1.00 (other)		Less than 0.01

_____ Pass _____ Fail

7. Bounce Test
   _____ Report Printed _____ Pass _____ Fail
   Comments: _____
8. Horizontal/DMI Calibration
   - A. _____ 528 feet (Calibration distance)
   - B. _____ Calibration Successful
   - C. _____ Report Printed

   Comments: _____

   Odomoter Mode Analysis

   A. _____ Distance Traveled (528±0.528 ft) B. _____ Report Printed

Certification Report Front
Figure 1A

9. Set-up Information Listed on Printed Report(s)

California Profilograph Settings:
Band Width (in.) = 0.20
Min. Scallop Width (ft) = 2.00
Min. Scallop Height (in.) = 0.030
Scallop Rounding = 0.05
Count Scallops Once = True

BUMP SETTINGS:
Bump Height (in.) = 0.3
Bump Width (ft) = 25.00
Bump Detection = on
Dip Detection = off

FILTER SETTINGS:
Low Pass Filter (ft) = 0.00
High Pass Filter (ft) = 300.00
Reduction Length = 528' English, 100 m Metric
Horizontal Scale = 300 to 1
Vertical Calibration = 1.000±0.01
Horizontal Calibration = 80±5

DYNAMIC TESTS

PROFILE INDEX FOR HIGHWAY 991		
TEST	INSIDE WHEEL PATH	OUTSIDE WHEEL PATH
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
AVERAGE		

10. Do the results generated by the alternate profilograph correlate to the results generated by the California Type Ames Profilograph to within 1.0 inch/mile for pavement surfaces which are up to 15 inches/mile in roughness? Yes _____ No _____
Were ten (10) runs performed for the determination? Yes _____ No _____
11. Does the alternate model demonstrate repeatability to within 1.0 inch/mile when testing pavements up to 15 inches/mile in roughness? Yes _____ No _____
Were ten (10) runs performed for the determination? Yes _____ No _____

IRI VALUES FOR BEN HUR ROAD		
TEST	INSIDE WHEEL	OUTSIDE WHEEL PATH
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
MEAN IRI	0.0	0.0
STD	??	??

IRI VALUES FOR HIGHWAY 991		
TEST	INSIDE WHEEL	OUTSIDE WHEEL PATH
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
MEAN IRI	0.0	0.0
STD	??	??

12. Precision: Is the standard deviation within the acceptable tolerance of the IRI? Yes _____ No _____
13. Bias: Is the mean IRI value within the acceptable tolerance of the Reference IRI Value? Yes _____ No _____

Remarks:

Inspected By: _____ Date: _____

Approved By: _____ Date: _____

Certification Report Back
Figure 1B

MATT MENU SELECTION - 11

DOTD 03-22-4035
Rev. 02/04

Louisiana Department of Transportation and Development

PORTLAND CEMENT CONCRETE PAVEMENT REPORT - 2000 Specifications

English / Metric E (*E or M - entry field located on MATT Menu*)

Project No. 999-999-99999 Mat Code 6511 Lot No. 1 Category I (*Spec. Cat. = I, II, III*)

Submitter Code 03718 Plant Code C361 Mix Des No. 024 Spec Code 1

Purp Code 3 Const.Method 1 (*1 - Slip Form 2 - Form 3 - Split Slab 4 - Contin. Reinforced 5 - Other*) Joints: Spacing 20 Configuration 1 (*1-Transverse 2-Skewed*)

Date 04-07-04 Item No. 601 (01) Lot Complete Y (*Y = Yes N = No*)

Remarks 1

From Station	To Station	Location	Width ft (m)	Thickness in (mm)	Area yd^2 (m^2)
178 + 039	231 + 019				
+	+				

PREVIOUS ______ yd2 (m2) + CURRENT ______ yd2 (m2) = Total to Date ______ yd^2 (m^2)

CURRENT ______ yd^3 (m^3) Theoretical Yield ______ yd^2/yd^3 (m^2/m^3) Actual Yield ______ yd^2/yd^3 (m^2/m^3)

% Air . . . . Slump, in (mm)

Joint Materials

	Material Code	Source Code	Source Name
Load Transfer Device			
Adhesive Lubricant			
Filler			
Sealer			

Curing

Curing Method ___ (*1 = Burlap 2 = Paper 3 = Poly Sheeting 4 = Burlap & Poly Sheeting 5 = Curing Membrane*)

Curing Membrane Rate ___ ft^2/gal (m^2/L)

Surface Texture

Applied By ___ (*1 = Manual 2 = Mechanical*) *Record Measurement to the Nearest 1/32 in (mm)*

Station ___ + ___ Location ___ Station ___ + ___ Location ___

1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 1 ___ 2 ___ 3 ___ 4 ___ 5 ___

Average ___ 1/32 in (mm) Average ___ 1/32 in (mm)

Surface Tolerance

Test Method 4 (*2 = Profilograph 3 = Static Straightedge 4 = Automated Profiler*)

Pavement Code 5 (*3 = Associated Pavement 5 = Travel Lanes, Greater Than 45 MPH 6 = Urban Areas, Continous Paving 45 MPH or Less 7 = Urban Areas, Non-Continous Paving 45 MPH or Less 8 = Tie-In Areas, Shoulders, Turnouts & Crossovers*)

Measured ___ lin ft (lin m) IRI 75 in/mi (mm/km) Avg Prof Index ___ in/mi (mm/km)

Remarks 2

% Pay ___

Laboratory Authorized Evaluator **Department's Certified Inspector**

District Laboratory Engineer **Project Engineer**

Portland Cement Concrete Pavement Report
Figure 2A

MATT MENU SELECTION - 18

Louisiana Department of Transportation and Development

SUPERPAVE ASPHALTIC CONCRETE ROADWAY REPORT

DOTD 03-22-4199
EST. 12/01

Metric/English [E] (M / E) *Located on MATT Menu*
Proj. No. [999-99-0099]
Purp Code [3] Previous Sublot *(Circle)*: 1 2 3 4 5
Spec Code [1]

Design Level [ ] **Lot No.** [ ]
Mix Type [ ] **SubLot** [ ]
Pav't Code [ ] **Submitter Code** [ ]
Plant Code [H823] **Mix Use** [ ] **JMF Seq No.** [ ]

From Station	178 + 039	To Station	231 + 019	Location	LRLL
From Station	+	To Station	+	Location	
From Station	+	To Station	+	Location	
From Station	+	To Station	+	Location	

Adjust. Factor
Proj Engr
Start Date
End Date

****** Yield ******

SqYds (sq m) [ ] Theo.Yield,in(mm) [•] Actual Yield [•] Dens.,%G_{mm} Req'd. ____ Avg Plant Max Gr.(G_{mm}) ____

******* Pavement Density ******

Sample No.	Date	Station	Thickness in. (mm)	Wt. (Mass) In Air (A)	Wt. (Mass) In Water (B)	Wt. (Mass) SSD (C)	Bulk Sp Gr (P) A / C- B	% Pav. Density (P/G_{mm} x 100)
			•					•
			•					•
			•					•
			•					•
			•					•

AVERAGE PAVEMENT DENSITY FOR LOT:

***** Project Quantity (tons) Mg ***** Previous** ____ **+ Portion of Lot Used (B)** [ ] **= Total to Date** ____

Sublot Remarks [ ]

****** Note: The remainder of this worksheet is to be reported on the Superpave Lot Average Screen (F10 Key) ******

***** Surface Tolerance *********** Avg.Profile Index, in/mi (mm/km)** [•] **IRI in/mi (mm/km)** [65•8] **% Pay** [90•0]

***** Plant Data ******************* Nominal Aggregate Size, in. (mm)** [ ] **Plant Quantity** [ ] **% Pay** [•]

Lot Remarks [ ]

Pay Item [ ] **APPROVED BY:** DIST. LAB ENGR. SIGNATURE

PLANT INSP SIGNATURE **RDWY INSP:** SIGNATURE **DATE:** 4-12-2004

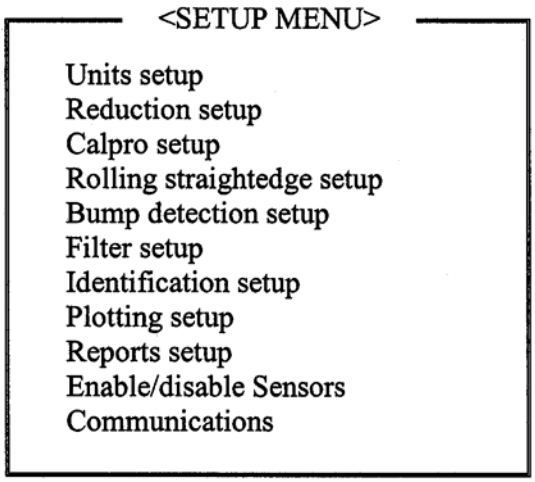
Asphaltic Concrete Pavement Report
Figure 2B

APPENDIX A – SET UP PROCEDURES

AMES INERTIAL SURFACE ANALYZER (LISA)

The following procedures allow the operator to change the various parameters that are used to collect, analyze, and report data using the AMES software versions 4.4, 4.61, and 4.8. For other versions, refer to the owner's manual for specific instructions to access each parameter. Table A-1 shows a summary of each parameter and the corresponding settings to be used.

Access the Setup menu from the main logo screen by pressing the SETUP (F1) key.



Setup Menu
Figure A-1

I. **Units:** The Units menu allows the operator to toggle between English or Metric units.

A. From the Setup Menu, select "Units Setup" and press enter.
B. Highlight either English or Metric, depending on the project requirements, and press enter.
C. Press F5 to return to the Setup Menu.

II. **Reduction Setup:** This option allows the operator to enter the reduction length. The reduction length is the segment length in which average IRI or PI results are calculated and reported by the computer.

A. Select "Reduction Setup" from the Setup Menu.
B. Highlight "Modify length" at the Reduction Menu and press enter.
C. Change the default value to 528 ft for PI measurements or 264 ft for IRI and press enter to return to the Reduction Menu.
D. Press F5 to return to the Setup Menu.

III. **Calpro Setup:** The Calpro option allows the operator to set parameters so that the profiler will simulate the 25 ft California Type Profilograph. Unless used as an alternate to the profilograph, these settings are not required. Otherwise, perform the following settings which are based on requirements shown in DOTD TR 641.

A. Select "Calpro Setup" from the Setup Menu and press enter to access the Calpro menu.
   1. Blanking Band Setup:

      a. At the Calpro menu, highlight "Blanking Band Setup" and press enter to access the B-Band Menu.
      b. Select "Modify With" and press enter. Enter 0.2 in. which is the blanking band width from DOTD TR 641 and press enter to save and return to B-Band Menu.

c. Highlight “Modify Positioning” and press enter. If the Off-Set Vertical box does not have a check mark, highlight the option and press enter to check the box.
d. Press F5 twice to return to the Calpro Menu.

2. Scallop Setup:
   a. At the Calpro Setup menu highlight “Scallop Setup” and press enter to access the Scallop Menu.
   b. Select “Minimum Scallop Height” and press enter. Enter 0.03 in. which is the minimum scallop height from DOTD TR 641 and press enter to save and return to the Scallop Menu.
   c. At the Scallop Menu, select “Scallop Width” and press enter. If the Minimum Scallop Width is not 2.000 ft, change to 2.000. Press enter to return to the Scallop Menu.

Note A-1: *Scallop width represents the minimum horizontal length of a scallop on the roadway that is used in calculating the profile index. This value corresponds to the minimum longitudinal length of 0.08 in. on the trace as shown in DOTD TR 641.*

   d. Select “Scallop Rounding” and press enter. If the Scallop Rounding is not 0.050 in. then change to 0.050. Press enter to return to the Scallop Menu.
   e. Select “Count Scallops Once.” If the box is not checked, press enter to place a check mark in the box. Otherwise proceed to Step f.
   f. Press F5 twice to return to the Setup Menu.

IV. **Bump Detection Setup:** Bumps can be analyzed by the computer by simulating the placement of a bump template over the profile at selected locations. This simulation can be applied to the California profilograph simulation or the true profile as obtained through IRI measurements. The operator must enter parameters for bump width & height as follows:

A. Select “Bump Detection Setup” from the Setup Menu and press enter to access the Bump Menu.
B. At the Bump Menu, highlight “Modify Bump/Dip Width” and press enter to access the current setting for bump/dip width. If the Bump Width is not 25.000 ft, change to read 25.000 and press enter to return to the Bump Menu.
C. At the Bump Menu, scroll to “Modify Bump/Dip Height” and press Enter. If the Bump Height is not 0.300 in., change to 0.300 and press enter to return to the Bump Menu.
D. If, at the Bump Menu, the check box for “Bump Detection On” is not checked, highlight the check box and press enter to turn on the bump detection system.
E. If, at the Bump Menu, the check box for “Dip Detection On” is not checked, leave as is (this detection is off).
F. Press F5 to return to the Setup Menu.

V. **Filter Setup:** The Filter Setup option allows the operator to set parameters for the Low Pass and High Pass Filters. The Low Pass Filter will filter out the effect of short wavelengths that are associated with rapid elevation changes, such as pavement joints, and unwanted vibrations from the California Profilograph trace. The High Pass Filter will filter out the effects of long wavelengths that are associated with elevation changes, such as horizontal curves and vertical curves on the trace.

A. Select “Filter Setup” from the Setup Menu and press enter to access the Filter Menu.
B. Select “High Pass Settings” and press enter. Verify the value shown for the high pass filter setting as being the same as that on the calibration tag located under the lid of the processor unit. If the High Pass Filter setting on the computer display does not match the value shown on the tag, enter the correct value and press enter to return to the Filter Menu.
C. At the Filter Menu select “Low Pass Settings” and repeat the process shown in Step B for the low pass filter setting.
D. At the Filter Menu, if measuring PI for concrete, turn the debris filter on. Otherwise, if measuring Pi for asphalt, IRI for asphalt, or IRI for concrete make sure that the “debris filter is off. To turn on the debris filter, highlight the “Debris Filter On” box and press enter.
E. Verify that there is no check mark in the box for Moving Average.
F. Press F5 to return to the Setup Menu.

VI. **Identification Setup:** The Identification Setup option allows the operator to enter the names of the profiler operator and the project contractor in addition to indicating the certification date of the profiler and Certification Number. The certification date and certification number are pre-entered at the time of calibration/verification by the Materials and Testing Section.

A. Select "Identification Setup" from the Setup Menu and press enter to access the Ident Menu.
B. At the Ident Menu, select the option for "Operator Name" or "Company Name" and enter the appropriate information. After each entry, press enter to save and return to the Ident Menu.
C. At the Ident Menu, select "Certification Number" and press enter. Verify that the Certification Number is the same as shown on the Certification Decal located in the gray processor box and on the Certification Report for the inertial profiler. Once verified, press enter to return to the Ident Menu.
D. At the Ident Menu, select "Certification Date" and press enter. Verify that the Certification Date is the same as shown on the Certification Decal located in the gray processor box and on the Certification Report. Once verified, press enter to return to the Ident Menu.
E. Press F5 to return to the Setup Menu.

VII. **Plotting Setup:** The plotting setup allows the operator to set the horizontal scaling, paper factor, and vertical offset parameters for plotting the profile trace. The horizontal scaling establishes the ratio of roadway travel distance to paper distance during plotting. The paper factor option allows the operator to compensate for paper slippage that may occur during plotting. Paper slippage can be caused by paper quality or temperature changes. The vertical offset parameter is used to shift the printed graph up or down on the page and in the graphics window on the computer display.

A. Select "Plotting Setup" from the Setup Menu and press enter to access the "Plotting" Menu.
B. At the Plotting Menu, select the option for "Horizontal Scaling" and press enter. The default setting is 300 to 1 (25 feet of road equals 1 inch of paper) and is the lowest scaling ratio allowed by the system. Higher values can be used to save paper. If a value greater than 300 to 1 is to be used, enter the appropriate value and press enter to return to the Plotting Menu.
C. At the Plotting Menu, select "Paper Factor" and press enter. The default value is 1.800, however if a different value is desired, enter the new value and press enter to return to the Plotting Menu.
D. At the Plotting Menu, select "Vertical Offset" and press enter. The default value is 200, however, if a different value is desired, enter the new value and press enter to return to the Plotting Menu.
E. Press F5 to return to the Setup Menu.

VIII. **Reports Setup:** The Reports Setup Menu allows the operator to select the type of information to be printed. The following steps represent the minimum settings needed to generate reports for IRI and PI. Other options, such as "Print Graph" can be selected at the Reports Menu, if needed.

A. Select "Reports Setup" from the Setup Menu and press enter to access the Reports Menu.
    1. For IRI reports:
        a. At the Reports Menu, select the following options:
            i. Print Sum Tables
            ii. Produce IRI/RN Tables
            iii. Produce CSV Tables
            iv. Header Long Form
            v. Dual Track Analysis (See Note A-2)
        b. Press F5 twice to return to the Main Menu screen.

    2. For PI reports:
        a. At the Reports Menu, select the following options:
            i. Print Graph
            ii. Print Sum Tables
            iii. Produce CSV Tables
            iv. Header Long Form
            v. Dual Track Analysis (See Note A-2).
            vi. Apply Calpro Sim
        b. Press F5 twice to return to the Main Menu screen

Note A-2: *If the option for Dual Track Analysis is not checked, then only the data obtained from ODS 1 (inside wheelpath or drivers side of the profiler) will be printed.*

IX. **Enable/Disable Sensors:** This allows the operator to choose which sensors will be operable during operation of the profiler. Power is not removed from the sensor when it is disabled using the Sensors Menu; however, the data will not be read during testing. For the purpose of this procedure, ODS Sensor 1 (inside wheelpath or driver's side of the profiler), ODS Sensor 2 (for measuring the outside wheelpath, if required), and Switch Pod should be activated by placing a check mark in the boxes.

X. **Communications Setup:** The Communications option allows the user to select which serial port on the laptop will be used to download data files and collect data. The settings are performed by the manufacturer and should not be changed in the field.

Model 6000

	IRI	**PI**
Units	English/Metric	English Metric
Reduction Length	264 ft	528 ft
Calpro: B-Band Width B-Band Position Scallop Height (min.) Scallop Width (min.) Scallop Rounding Count Scallops Once		 0.2 in. Offset Vertical 0.03 in. 2.000 ft 0.05 in. ON
Bump Detection: Bump/Dip Width Bump/Dip Height Bump Detection	 25.000 ft 0.300 in. ON	 25.000 ft 0.300 in. ON
Filter Settings: High & Low Pass Debris Filter Moving Average	 See Calib Data ON OFF	 See Calib Data ON OFF
Identification: Operator/Company Certification No. Calibration Date	 Enter Info See Calib Data	 Enter Info See Calib Data
Plotting Setup: Horizontal Scaling Paper Factor Vertical Offset	 300:1 1.800 200	 300:1 1.800 200
Reports Setup: Print Graph Print Sum Tables Produce IRI Tables Produce CSV	 Optional On On On	 On On Off On
Tables Header Long Form Dual Track Analysis	 On On	 On See Specs
Enable/Disable Sensors ODS 1 ODS 2 Switch Pod	 On On On	 On See Specs On

AMES LISA PROFILER
Summary of Settings
Table A-1

APPENDIX B – PRE-OPERATION TESTS

AMES INERTIAL SURFACE ANALYZER (LISA)

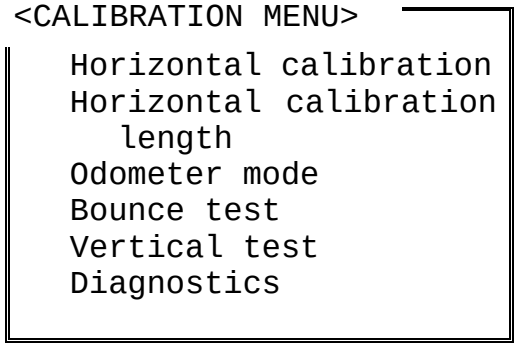
The following procedures allow the operator to perform pre-operation verification and calibration tests on the AMES LISA profiler data acquisition system.

The manufacturer's recommended profiler travel speed is from 8 – 12 mph. When taking surface roughness measurements, the profiler speed shall be maintained within these limits.

With the exception of the Diagnostics Test, reports for the pre-operation tests must be printed and provided to the Project Engineer as verification that the profiler has been calibrated correctly.

Note B-1: *After the test results of each of the following tests are printed, the computer will automatically return to the Calibration Menu.*

Access the Calibration menu (Figure B-1) from the main logo by pressing the Calibration (F2) key.



Calibration Menu
Figure B-1

I. **DIAGNOSTICS TEST:** The diagnostics test allows the operator to check the status of the sensors that are connected to the data acquisition system.

A. At the Calibration Menu, scroll to "Diagnostics" and press the enter key. This will open the Slave Diagnostics Table (Figure B-2).
B. Look under the 3 columns labeled "**ODS 1"**, "**ODS 2"**, and "**SWITCH POD"**. Under the ODS 1 and ODS 2 columns, errors should equal 0 (ERRORS=0). Check for errors under the SWITCH POD heading by pressing the green, black, and red buttons, located to the left of the steering wheel, 1 button at a time. When the green button is pressed, "CHKSUM" should equal 1 (CHKSUM = 1) and "DATA" should equal 1 (DATA = 1). When the black button is pressed, CHKSUM should equal 2 (CHKSUM = 2) and DATA should equal 2 (DATA = 2). When the red button is pressed, "CHKSUM" should equal 4 (CHKSUM = 4) and "DATA" should equal 4 (DATA = 4).

Note B-2: *If the readings obtained during the diagnostics tests are not as noted above, then the device fails and the manufacturer must be contacted. If the device fails the diagnostic test, then it cannot be used for surface measurements and no further calibration or verification shall be performed.*

ODS 1	ODS 2	SWITCH POD
Chksum = Errors = Data =	Chksum = Errors = Data =	Chksum = Errors = Data =
AUTO ST/SP	AUTO MARK	AUX
Chksum = Errors = Data =	Chksum = Errors = Data =	Chksum = Errors = Data =

Slave Diagnostics Table
Figure B-2

II. **VERTICAL MEASUREMENT TEST:** The vertical measurement test verifies that each displacement sensor (ODS1 and ODS2) is working properly by taking thickness measurements of the base plate and metal calibration blocks.

Note B-3: *The operator should not be inside the vehicle during testing.*

A. From the Calibration Menu, select “Vertical Test” and press enter.
B. From the Vertical Test options, select “Extensive Test” and press enter.
C. Place the metal base plate under ODS 1 which is the sensor located underneath the profiler on the driver’s side. When placing the base plate, make sure there is no foreign matter, such as grains of sand or pebbles, under it that can cause movement of the base plate. The slightest movement of the base plate during this test will cause failing results.
D. Visually verify that the red laser dot appears on the base plate. If no red dot appears, verify that the protective cover is not obstructing the laser and that the processing unit is still on since this controls the power to the laser.

Note B-4: *If the processing unit is turned on and the protective cover removed and no laser dot is visible, call the manufacturer. Do NOT proceed.*

E. Press the space bar once so that 10 distance measurements are taken on the base plate.
F. When prompted by the computer, place the 0.25 inch calibration block on top of the base plate such that the red dot appears on the approximate center of the calibration block.
G. Press the space bar once so that 10 distance measurements are taken on the combination base plate and 0.25 inch block.
H. Repeat steps F and G using the 0.50 inch calibration block in place of the 0.25 inch block.
I. Repeat steps F and G using the 1.00 inch calibration block in place of the 0.25 inch block.
J. Place the metal base plate under the ODS 2, located on the passenger side of the vehicle, and repeat steps D thru I.
K. After the vertical test for ODS 2 is completed, the computer will display, “Do you want to print?” Press “Y” to print.
L. Remove printed test results from printer located in the processing computer box in the rear of the vehicle.
M. Review the results. The results for each ODS are printed in table form similar to Figure B-3. The average difference per block thickness shown at the bottom of each table shall not exceed 0.01 inch for any block size.

<VERTICAL MEASUREMENT TEST ODS1>

	Block to Measure (in.)			
Record	Base	0.25	0.50	1.00
1	0.385	0.635	0.885	1.380
2	0.380	0.630	0.885	1.375
3	0.380	0.635	0.885	1.380
4	0.380	0.635	0.885	1.375
5	0.375	0.630	0.890	1.380
6	0.385	0.635	0.885	1.380
7	0.375	0.630	0.885	1.380
8	0.380	0.640	0.885	1.385
9	0.375	0.635	0.880	1.380
10	0.380	0.635	0.885	1.380
Avg. Diff.		0.005	0.006	0.004

Vertical Test
Figure B-3

Note B-5: *Movement of the profiler or calibration blocks can cause failing results during the vertical test. The accelerometer compensates for variations in horizontal and vertical movement of the profiler during the performance of the surface roughness test. Since the profiler is stationary during the pre-operative vertical test, failing results may be caused by the wind. Also, damaged calibration blocks may cause failing results. Therefore, if the values shown for Average Difference are greater than 0.01 inch between block sizes, relocate the device where wind is not a factor or change calibration blocks and repeat the vertical test. However, radical changes in the Average Differences, indicate equipment malfunction and the manufacturer should be notified.*

III. **VERTICAL BOUNCE TEST:** The bounce test allows the operator to verify the interaction of the optical displacement sensor(s) and accelerometer(s) such that vehicle bounce is cancelled out during actual surface roughness testing. This test simulates the accumulation of data over a 500-ft test section even though the vehicle remains stationary during the test.

A. Make sure that the vehicle is on level ground and the front wheels of the profiler are aligned straight ahead. Position the differential lever, located between the driver and passenger seats, in the unlock position.
B. From the Calibration Menu, scroll to “Bounce Test” and press enter.
C. Stand in the middle of the vehicle, between the driver and passenger seats, press the space bar, and bounce straight up and down such that the vehicle moves in a vertical direction only. Do not bounce the vehicle side to side. The computer display will show a simulated profile of data as the bounce test is being performed.
D. Continue the vertical movement of the vehicle until the computer beeps, simulating the completion of a 500 ft test section.
E. After the computer beeps, look at the computer screen for the results. At the end of the graphical display, the printout should indicate “**ODS 1 PASSED”** and “**ODS 2 PASSED”** (Figure B-4**)**. If this occurs, press the space bar and press “Y” to print the report. If a failing result is displayed for either sensor, wait 5 minutes to allow the accelerometers to stabilize, press F2 to return to the Calibration menu and repeat steps B thru E until both non-contact sensors pass.

Note B-6: *Extreme care should be taken to ensure that the bounce test is performed while standing in the center of the profiler between the driver and passenger seats and that only vertical movement occurs. Any side-to-side movement will cause failing results. If, after several attempts, passing results cannot be obtained for either sensor, then the manufacturer should be notified.*

```
< VERTICAL BOUNCE TEST >

ODS 1     PASSED    RQI = 0.00

ODS 2     PASSED    RQI = 0.00
```

Bounce Test
Figure B-4

IV. **HORIZONTAL CALIBRATION:** The following steps will calibrate the distance transducer on the profiler over a pre-determined distance along a straight section of roadway. Daily calibration compensates for changes in tire pressure and tire wear on the profiler.

A. Use a measuring tape to establish a marked distance of at least 528.0 ft along a straight section of the surface to be measured for surface roughness.
B. From the Calibration Menu, scroll to "Horizontal Calibration Length" and press enter.
C. The default Horizontal Length should be shown as 528 ft. If the distance measured in Step A is greater than the default value, enter the actual distance measured as the Horizontal Length and press F5 to return to the Calibration Menu.
D. At the Calibration Menu, scroll to "Horizontal Calibration" and press enter.
E. Position the profiler at the beginning point of the measured distance in Step A. Align any point on the profiler with the beginning point (Note B-7) of the marked distance.

Note B-7: *Any point on the vehicle can be used as a reference as long as the operator is consistent in using this point as the reference in Steps E & H. It is best to use something on the profiler that is close to the operator so that errors in judgment can be eliminated.*

F. Press the space bar or the green switch pod button that is located to the left of the steering wheel to begin recording the horizontal travel distance.
G. Accelerate the profiler to any desired speed along the marked distance. The traveled distance must be in a straight line between the beginning and ending points of the section. An alignment bar, attached to the front bumper of the profiler, can be used to accomplish this.
H. When approaching the ending point of the marked distance, slow the profiler and stop so that the point on the profiler that was used to align it with the beginning point in Step E is aligned with the ending point of the marked distance. Press the space bar or the red switch pod button to record the total distance traveled.
I. The computer will display "Do you want to print?" Press "Y" to print.
J. Review the printed results (Figure B-5). If the calibration was successful, the printed results will read, "Calibration Successful." If the calibration was not successful, the printed results will read, "Calibration Unsuccessful." If the calibration was successful, proceed to Step V to check the Odometer Mode. If the calibration was unsuccessful, repeat steps A through J above until the calibration is successful.

```
< HORIZONTAL CALIBRATION RESULTS >

Calibration Distance =  528.00 ft.
Pulses counted    =   5313
Horizontal calibration factor     =   80.5000

Calibration Successful
```

Horizontal Calibration
Figure B-5

V. **ODOMETER MODE:** This procedure will allow the operator to test the accuracy of the horizontal calibration by measuring the distance marked off in Step IV.A using the odometer on the profiler.

A. Position the profiler at the beginning point of the measured distance that was marked in Step IV.A. Align any point on the profiler (Note B-6) with the beginning point.
B. At the Calibration Menu, scroll to "Odometer Mode" and press enter.
C. Enter a convenient starting station (example: 10+00) and press enter.
D. On the computer screen, highlight "+" to increment the distance traveled as the profiler moves forward.
E. Press the space bar or the green switch pod button to begin measuring the travel distance.
F. Accelerate the profiler to any desired speed along the marked distance. The traveled distance must be in a straight line between the beginning and ending points of the test section. An alignment bar, attached to the front bumper of the profiler, can be used to accomplish this.
G. When the point on the profiler that was used to align the profiler with the beginning point in Step F reaches the ending point of the measured distance, press the space bar or the red switch pod button to record the total distance traveled.
H. In addition to the distanced traveled, the computer will display "Do you want to print?" Press "Y" to print. The traveled distance must be within ±0.1% of the actual distance measured in Step IV.A.

Note B-8: *An error larger than 0.1% of the actual distance shall not be accepted. If the odometer indicates that the traveled distance exceed the specified limits in Step H, check the distance measured in Step IV.A. If necessary, repeat the Horizontal Calibration and Odometer Mode tests until an error less than or equal to 0.1% of the actual distance is indicated by the odometer. If after three unsuccessful attempts the error still exceeds 0.1%, notify the manufacturer and discontinue use of the profiler.*